Electronic Version
Stylesheet Version v1.1.1

Claims

[c1] 1.A transducer assembly comprising:
a transducer to excite bending waves in an acoustic radiator to produce an acoustic output; and
a coupler including rheological material, the coupler mounted to the transducer and adapted to be operatively connected to the acoustic radiator to transmit bending wave energy from the transducer to the acoustic radiator.

[c2] 2.The transducer assembly of claim 1, wherein the rheological material is magneto-rheological fluid and further comprising a magnet for generating a magnetic field through the coupler, and wherein the magneto-rheological fluid has a controllable viscosity that increases in response to the magnetic field, such that the coupler is substantially flexible in the absence of the magnetic field and is substantially rigid in the presence of the magnetic field.

[c3] 3.The transducer assembly of claim 2, wherein the magnet is an electromagnet.

[c4] 4.The transducer assembly of claim 2, wherein the mag-

net is a permanent magnet and further comprising means for moving the permanent magnet between first and second positions, the first position disposed relative to the coupler such that the magnetic field passes through the coupler with sufficient strength to make the coupler substantially rigid, and the second position disposed relative to the coupler such that the magnetic field does not pass through the coupler with sufficient strength to make the coupler substantially rigid.

[c5] 5.The transducer assembly of claim 4, wherein the means for moving the permanent magnet comprises a solenoid.

[c6] 6.The transducer assembly of claim 1, wherein the rheological material is electro-rheological fluid and further comprising electric leads adapted to generate an electric field through the coupler, and wherein the electro-rheological fluid has a controllable viscosity that increases in response to the electric field, such that the coupler is substantially flexible in the absence of the electric field and is substantially rigid in the presence of the electric field.

[c7] 7.The transducer assembly of claim 1, wherein the transducer includes a piezoelectric element.

[c8] 8.The transducer assembly of claim 1, wherein the coupler comprises foam impregnated with rheological material.

[c9] 9.The transducer assembly of claim 1, wherein the coupler comprises a closed vessel including a compliant body containing rheological material.

[c10] 10.A transducer assembly comprising:
a piezoelectric transducer to excite bending waves in an acoustic radiator to produce an acoustic output;
a coupler including foam impregnated with a magneto-rheological fluid, the coupler mounted to the transducer and adapted to be operatively connected to the acoustic radiator to transmit bending wave energy from the transducer to the acoustic radiator; and
a magnet for generating a magnetic field through the coupler,
wherein the magneto-rheological fluid has a controllable viscosity that increases in response to the magnetic field, such that the coupler is substantially flexible in the absence of the magnetic field and is substantially rigid in the presence of the magnetic field.

[c11] 11.A loudspeaker comprising:
an acoustic radiator adapted to support bending wave vibration;

a transducer to excite bending waves in the acoustic radiator to produce an acoustic output; and
a coupler including rheological material, the coupler operatively connected to the acoustic radiator and the transducer to transmit bending wave energy from the transducer to the acoustic radiator.

[c12] 12.The loudspeaker of claim 11, further comprising means for generating an energy field through the coupler, and wherein the rheological material has a controllable viscosity that increases in response to the energy field, such that the coupler is substantially flexible in the absence of the energy field and is substantially rigid in the presence of the energy field.

[c13] 13.The loudspeaker of claim 11, wherein the acoustic radiator is at least in part transparent.

[c14] 14.The loudspeaker of claim 13, wherein the acoustic radiator includes a display.

[c15] 15.The loudspeaker of claim 14, wherein the display is a liquid crystal display.

[c16] 16.The loudspeaker of claim 11, further comprising a display and a window mounted over the display, wherein the window is the acoustic radiator.

[c17] 17.The loudspeaker of claim 11, wherein the transducer includes a piezoelectric element.

[c18] 18.The loudspeaker of claim 11, wherein the coupler comprises foam impregnated with rheological material.

[c19] 19.A loudspeaker comprising:
an acoustic radiator adapted to support bending wave vibration and selected from the group consisting of a display and a window mounted over a display;
a piezoelectric transducer to excite bending waves in the acoustic radiator to produce an acoustic output;
a coupler including foam impregnated with rheological material, the coupler operatively connected to the acoustic radiator and the transducer to transmit bending wave energy from the transducer to the acoustic radiator; and
means for generating an energy field through the coupler,
wherein the rheological material has a controllable viscosity that increases in response to the energy field, such that the coupler is substantially flexible in the absence of the energy field and is substantially rigid in the presence of the energy field.

[c20] 20.A mobile terminal comprising:
a housing;
a loudspeaker mounted to the housing, including:

an acoustic radiator adapted to support bending wave vibration and selected from the group consisting of a display and a window mounted over a display;
a transducer to excite bending waves in the acoustic radiator to produce an acoustic output; and
a coupler including rheological material, the coupler operatively connected to the acoustic radiator and the transducer to transmit bending wave energy from the transducer to the acoustic radiator.

[c21] 21.The mobile terminal of claim 20, wherein the rheological material is magneto-rheological fluid and further comprising a magnet for generating a magnetic field through the coupler, and wherein the magneto-rheological fluid has a controllable viscosity that increases in response to the magnetic field, such that the coupler is substantially flexible in the absence of the magnetic field and is substantially rigid in the presence of the magnetic field.

[c22] 22.The mobile terminal of claim 21, wherein the magnet is an electromagnet.

[c23] 23.The mobile terminal of claim 20, wherein the rheological material is electro-rheological fluid and further comprising electric leads adapted to generate an electric field through the coupler, and wherein the electro-

rheological fluid has a controllable viscosity that increases in response to the electric field, such that the coupler is substantially flexible in the absence of the electric field and is substantially rigid in the presence of the electric field.

[c24] 24.The mobile terminal of claim 20, wherein the display is a liquid crystal display.

[c25] 25.The mobile terminal of claim 20, wherein the transducer includes a piezoelectric element.

[c26] 26.The mobile terminal of claim 20, wherein the coupler comprises foam impregnated with rheological material.

[c27] 27.A mobile terminal comprising:
a housing;
a loudspeaker mounted to the housing, including:
an acoustic radiator adapted to support bending wave vibration and selected from the group consisting of a display and a window mounted over a display;
a piezoelectric transducer to excite bending waves in the acoustic radiator to produce an acoustic output;
a coupler including foam impregnated with rheological material, the coupler operatively connected to the acoustic radiator and the transducer to transmit bending wave energy from the transducer to the acoustic radiator; and

means for generating an energy field through the coupler,

wherein the rheological material has a controllable viscosity that increases in response to the energy field, such that the coupler is substantially flexible in the absence of the energy field and is substantially rigid in the presence of the energy field.

[c28] 28.A method of making a loudspeaker, comprising:

providing an acoustic radiator adapted to support bending wave vibration;

providing a transducer to excite bending waves in the acoustic radiator to produce an acoustic output;

operatively connecting a coupler including rheological material to the acoustic radiator and to the transducer to transmit bending wave energy from the transducer to the acoustic radiator; and

providing means for generating an energy field through the coupler, and wherein the rheological material has a controllable viscosity that increases in response to the energy field, such that the coupler is substantially flexible in the absence of the energy field and is substantially rigid in the presence of the energy field.

[c29] 29.A method of producing sound with a device, comprising:

sending an electrical audio signal to a transducer to cre-

ate bending wave energy;
generating an energy field to cause a coupler including rheological material to become substantially rigid; and transmitting bending wave energy from the transducer through the coupler to an acoustic radiator to excite bending waves to produce an acoustic output.

[c30] 30.The method of claim 29, further comprising reducing the strength of the energy field to cause the coupler to become substantially flexible.

[c31] 31. The method of claim 30, wherein generating an energy field comprises generating a magnetic field, reducing the strength of the energy field comprises reducing the strength of the magnetic field, and the rheological material is magneto-rheological fluid.

[c32] 32.The method of claim 30, wherein generating an energy field comprises generating an electric field, reducing the strength of the energy field comprises reducing the strength of the electric field, and the rheological material is electro-rheological fluid.

[c33] 33.The method of claim 30, wherein the device is a mobile terminal, generating an energy field occurs when the mobile terminal is on a call, and reducing the strength of the energy field occurs when the mobile terminal is not

on a call.